

Distinguishing between Observationally Equivalent Theories of Crises

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The World Bank
Latin America and the Caribbean Region
Office of the Chief Economist
November 2002



Abstract

The objective of this paper is to empirically test across alternative, apparently observationally equivalent theories of currency crises. Theories of crises are often difficult to distinguish from each other based on the behavior of commonly used predictors. Using a comprehensive data set on gross external assets and liabilities for 167 countries created by the World Bank's Latin America and the Caribbean Region and the

Development Research Group, this study is able to make a significant move toward redressing this shortcoming. It focuses on identifying potential crisis predictors, as well as testing the validity of the distinct transmission mechanisms implied by various theories of currency crisis. Evidence is presented in support of insurance-based models, suggesting that proxies for contingent liability accumulation are effective crisis predictors.

This paper—a product of the Office of the Chief Economist, Latin America and the Caribbean Region—is part of a larger effort in the region to promote a deeper understanding of the causes and consequences of balance-of-payments crises. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Patricia Holt, room I8-168, telephone 202-473-7707, email address pholt@worldbank.org. Policy Research Working Papers are also posted on the Web at <http://econ.worldbank.org>. The author may be contacted at rshankar@worldbank.org. November 2002. (38 pages)

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Distinguishing Between Observationally Equivalent Theories of Crises

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Keywords: identification, expectations, currency crises, growth effects, panel estimation

JEL Classification: C230, C330, C350, F310

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1: Introduction

The objective of this paper is to empirically test across alternative, apparently observationally equivalent theories of currency crises that are often difficult to distinguish from each other based on the behavior of commonly used predictors. Using a new, comprehensive data set on gross external assets and liabilities for 167 countries, this study is able to make a significant move towards redressing this shortcoming. The focus is on identifying potential crisis predictors as well as testing the validity of the distinct transmission mechanisms implied by various theories of crisis. There is strong evidence in support of insurance-based models suggesting that proxies for the accumulation of contingent liabilities are an effective crisis predictor.

There is a large and growing literature that emphasizes the role of capital flows and/or imperfect domestic financial intermediation in generating crises. This “third-generation” of currency crisis models (Dooley, 1997; Chang and Velasco, 1998; Calvo, 1993), focuses on the central bank’s function as lender of last resort as a contributing factor to moral hazard in domestic banking (insurance models), mismatched external assets and liabilities (illiquidity models) and volatile capital flows to emerging markets in fixed exchange rate environments (“sudden stop” models and the literature on the optimal sequencing of capital account liberalization). Common prescriptions are imposing capital account restrictions and IMF lending to bolster international reserves.

No one would disagree that a well-regulated, deep financial sector is desirable. But in policy prescriptions, what weight should be assigned to central bank guarantees, or to the accumulation of net short-term debt by the domestic banking sector? Certainly, they are closely related, but the relevant institutional response would be different. In the absence of exchange or capital controls, any convertible exchange rate will ensure that the economy is illiquid always. The central bank must stand ready to exchange domestic currency for its liquid foreign assets even though its currency liabilities will always be the greater of the two quantities. Since a currency crisis is always a potential equilibrium under this logic, the root of the problem is likely to lie elsewhere, say in insurance/moral hazard, or in domestic banking failures or in inconsistent domestic macroeconomic policies. A related question is

that of the effectiveness of capital account restrictions. Policy formulations require a clear understanding of the underlying causes of the crisis. However, distinguishing across the transmission mechanisms of many of these models requires data that is not readily available, which is precisely the main theme of this paper.

The rest of this paper is structured as follows. Section 2 briefly reviews the empirical literature on the prediction of currency crises. Section 3 describes the motivation behind this paper and its contribution to the existing literature. Section 4 describes the empirical methodology and data used in testing across theories of crises. Section 5 presents the results of the probit model estimations of alternative crisis specifications. Section 6 describes the results of the endogeneity tests between growth and occurrence of a currency crisis, and of the bivariate probit model used to jointly estimate the likelihood of a currency crisis and of a slowdown in growth or a recession. Section 7 concludes and the appendix contains details of the construction of the variables, estimation output, and summary of empirical tests in the existing literature.

2: Literature Review:

A. Crisis Predictors and Early Warning Indicators

A.1: Review of Earlier Empirical Work: This section presents a summary of the theories of crisis, as distinguished by their particular transmission mechanisms and empirical implications. The purpose is to shed some light on how we can distinguish across seemingly observationally equivalent theories of crisis with the new variables in the data set. Table 2 provides a comparison how this database on net and gross foreign asset positions allows improved identification of the distinct transmission mechanisms implied by seemingly similar theories of currency crises.

Some other studies have used similar variables to predict crises. Most studies include “capital account” variables in their analysis. Ten of the sixteen studies surveyed by Kaminsky *et al* (1996) include international reserves, either as a proportion of imports or of GDP, and all find it a statistically significant predictor. Otker and Pazarbasioglu (1994 and 1995) find evidence in support of the interest rate and inflation differential with the United States being relevant

predictors. In addition, several studies (Eichengreen, Rose and Wyplosz (1995 and 1996), Milesi-Ferretti and Razin (1995), Otker and Pazarbasioglu (1995), Kaminsky and Reinhart (1996), find support for including past crises as predictors.

Demirguc-Knut and Detragiache (1998) also use a probit analysis but with a broader set of variables than Kaminsky and Reinhart (1996 and 1998) who focus on the relationship between banking and currency crises and on the impact of financial liberalization (which is the only significant predictor of banking crises in their study). Demirguc-Knut and Detragiache (1998) study a panel of 53 countries over the period 1980-95. One of the key factors in banking crisis prediction according to them is external vulnerability measured by broad money to international reserves.

Edwards (1989) finds that the probability of devaluation is affected predictably by the variable net foreign assets/M1. Klein and Marion (1994) also find that the ratio of net foreign assets of the monetary sector to M1 is a significant predictor as is the same ratio squared. The latter however is not robust to changes in the specification. Net foreign asset positions conceal some useful information about what is really going on; additionally, the Edwards (1989) and Klein and Marion (1996) studies had limited coverage since data on net foreign asset positions (henceforth NFAs) is readily available for only a limited number of countries. Frenkel and Rose (1996) estimate a multivariate probit to find that concessional debt/total debt, foreign direct investment/total debt and foreign interest rates all help predict crises one year in advance. However, these studies rely either on short-term external debt data as reported by member countries to the World Bank or net capital flows (readily available from the International Financial Statistics of the IMF, hereafter IFS) and their composition.

Kaminsky and Reinhart (1998) do not include any financial flows in their regressions. Corsetti, Pesenti and Roubini (1998), include short-term foreign debt, and non-performing loans as a proportion of bank assets (as a proxy for weakness in the domestic banking sector). Their data on the banking sector is useful. They primarily base their information on domestic banks' external liabilities to foreign banks in 18 developed countries. Their figures match the World Bank-IMF-BIS database on external liabilities. Their coverage though is poor, and

suffers from two major shortcomings. First, they have a sample of nine “crisis” countries. This raises problems of overestimation of the effect of the included regressors. Second, they consider a very short time series.

It is important to emphasize that when one is discussing “third-generation” models, a common feature in their transmission mechanisms (Dooley, 1998; Chang and Velasco, 1997; Kletzer and Chinn, 1999) is the existence of a potential crisis equilibrium whose timing depends on something not quite captured by fundamentals as typically defined in first generation crises. Domestic investors perceive that the economy as a whole is “illiquid” (Chang and Velasco, 1997), and that a “run on the central bank” would be self-validating. Alternatively, they decide that the government's contingent liabilities from their implicit (or explicit) commitment to insuring the domestic financial sector are hitting a threshold level, so a speculative attack would work (Dooley, 1998). In a similar, analytically more formal model, the failure of the banking sector is endogenized so that the crisis is due to the government's expected monetization of the banking sector losses, while the losses themselves arise because asymmetric information introduces adverse selection incentives. (Kletzer and Chinn, 1999).

A.2: The Insurance Model: In all of the post-Asian crisis theories, the government's or the banking sectors balance sheet is a key factor in determining whether a crisis will occur. This is emphasized in the insurance model as well (Dooley, 1998). In this model, the crisis occurs because of the conflict between two government objectives: the desire to insure domestic residents' liabilities and the need to accumulate liquid assets. The government's insurance of the financial sector (banks and non-bank financial intermediaries) raises the yield on domestic assets above the international risk-free interest rate. This yield differential gets smaller and then is reversed as the government's contingent liabilities approach, and then increase to a level greater than its reserves. If the government insures a proportion of total external liabilities, this suggests that the economy's *gross* liabilities determine the size of the claims on the government, and in conjugation with reserves, the timing of the crisis. This is especially true if there is a ceiling on the extent to which private assets can be appropriated.

This argument is consistent with an increase in private capital inflows before the crisis; a stylized fact associated with the currency crisis episodes of the eighties and nineties.

Capital flight in this context becomes both, a measure of private expectations regarding the exchange rate and the future relative price of domestic and foreign assets, and a measure of domestic agents' ability to prevent expropriation of their assets.

Thus, to test the insurance model one would like to have access to data on capital flight, measured consistently across a large sample of countries, and gross foreign liabilities, stocks as well as flows.

Ideally, the insurance logic could also be tested using some criteria of bank inefficiency such as non-performing loans, or by using banking crises as a proxy for a weak financial sector, since a test of Granger causality can be used to check that currency crises are not the source of banking crises. At the same time, there are arguments that a banking crisis can occur if a devaluation spirals up the liabilities side of the financial sector's balance sheet. This is also however an indication of an imperfection in the domestic banking sector, since in a perfect world there should be risk pooling, so banks would insure themselves against exchange-risk. While the database developed by Caprio *et al* (World Bank, 2001), fills a useful gap, it is noteworthy that the countries surveyed mostly refused to disclose any information in their response to the question on non-performing loans.

A.3: The Illiquidity Model: The stylized fact that currency crises are associated with a cessation or reduction in capital inflows implies, by definition, that there must be a decrease in the current account deficit or in foreign reserves or both. If the exchange rate is pegged, the authorities are intervening in the exchange market to adjust quantities, as prices cannot change. This makes the central bank vulnerable to runs since any reallocation of portfolios away from domestic assets involves a fall in their international reserves. The central bank, as lender of last resort, is committed to stand ready to swap its foreign assets for domestic currency. The entire stock of domestic currency is the liability of the monetary authorities. Thus, the absence of capital restrictions generates a situation that is similar to that of an

ordinary bank having only liquid liabilities. While the monetary authorities have liquid assets as well, the stock of these is typically greatly exceeded by the stock of their liquid liabilities. Thus, a run on the central bank can be thought of as one of multiple potential outcomes. In addition, if an economy's short-term foreign liabilities exceed the short-term foreign assets it can lay its hands on if its creditors pull out, a speculative attack is likely to succeed. Borrowing foreign reserves only increases the central bank's foreign denominated liabilities while increasing at the same time the economy's monetary base.

Another implication of the theory is that capital controls should succeed in preventing a crisis, by limiting the extent to which foreign liquid assets are moved out of the country, and also by potentially restricting the amount of its obligations that the central bank would need to "repay" in a given time period.

Thus, to test the illiquidity model we need to use net short-term external liabilities since this defines the range of fundamentals over which a currency crisis is more likely to occur.

3. 2 Motivation and Contribution to the Literature:

The first aim of this paper is to distinguish across similar models of crises by their transmission mechanisms. In particular, the objective is to test across the "third generation" of currency crisis models. These are modified first generation models in which the focus is on the macroeconomic implications of the inconsistency introduced by the insolvency, or perceived insolvency, of the central bank, the domestic banking sector or the economy as a whole.

In this context we should first define what we mean by observationally equivalent. As an example, consider the insurance model (Dooley, 1997). Here the crisis takes place because the government's contingent liabilities, arising from its function as lender of last resort to the domestic financial sector, are greater than its assets. Additionally, while contingent liabilities rise with private sector borrowing, the central banker need not be able to appropriate domestic assets. A "run" on the central bank becomes one of many possible equilibria. This is empirically difficult to distinguish from the quasi-fiscal deficit generated by the government's

monetization of the banking sector's losses. The monetization occurs because of implicit guarantees of the domestic financial sector, as in Kletzer and Chinn (1999). This type of model formalizes the logic behind the insurance model, while endogenizing the imperfection in the banking system that generates the crisis. Moral hazard is attributable to the banks' incentive to accept greater risk since there is a lower bound on the assets that can be appropriated from them. In this category of models, the interaction between the financial and the currency crisis is clearly highlighted. It is easier to distinguish these two models observationally from Chang and Velasco's (1997) liquidity crisis model, which takes as exogenous the imperfections in the domestic financial sector, and models the crisis as a mismatch between liquid assets and liabilities. Here the focus is on net short-term liabilities, while under the insurance model, the predictor would be gross liabilities, and some measure of portfolio risk.

In Chinn, Dooley and Shreshtha (1998), Dooley's insurance model is tested with data on total domestic credit to the banking sector. Since total domestic credit largely consists of domestic credit to the banking sector, this test of the insurance model is in effect a test of the standard first-generation model¹. Moreover, movements in this variable are strongly correlated with movements in the growth of total domestic credit, often used to test the standard first-generation model. Growth in total domestic credit to the private sector and total domestic credit are correlated also with the evolution of total liabilities of the private sector, which are the focus of the illiquidity model.

Chinn, Dooley and Shreshtha (1998) use capital flight as a proxy for the private sector's ability to appropriate assets from the government as a means of preservation from a "devaluation" tax. An increase in capital flight before the currency crisis is also an indicator of exchange risk expectations. This variable can therefore be used as a proxy for expectational shifts. In the model developed in Shankar (2001), residents can use "capital flight" to protect their welfare, though this lowers domestic investment and growth over

¹ Let the model be $Y = \beta X' + \gamma$, where X is the matrix of explanatory variables and γ is a serially uncorrelated vector of disturbances. Now suppose that the variables in Z are functions of the variables in X such that $Z = \delta X' + \mu$. Substituting in the model, we get $Y = (\beta/\delta)Z' + \xi$, where $\xi = \gamma + (1/\delta)\mu$. Thus, using Z and X is effectively the same model.

certain ranges of fundamentals. The expected devaluation introduces the motive to place assets abroad and smooth consumption to whatever extent possible given transactions constraints.

As is necessary to distinguish across models, alternative specifications must have at least one unique identifying exogenous variable in each case. These focus variables include measures of capital flight, net external debt and gross external liabilities. This is because, as demonstrated in sections 2 and 3, there is a need to consider changes in gross foreign asset and liability positions, gross foreign asset and liability flows and the term structure of gross liabilities. Gross debt is adjusted for forgiveness and arrears on interest and principal. Considering only net changes results in a loss of information as highlighted in the review of the “third-generation models” that are the focus of this paper.

B. Contribution to the literature

(1) The construction of the data set allows me to be able to test across seemingly observationally equivalent theories of currency crises by distinguishing patterns in the data not previously available. The data includes gross asset and liability positions for all the countries in the sample based on which net foreign asset positions were constructed for a significantly larger number of countries than was available earlier. This allows a direct comparison of the validity of different indicators as sources of shifts in expectations.

(2) This new database enables us to distinguish between theories of crises more effectively than in previous studies. This is especially relevant in disentangling the various first and modified first generation theories. This is done by identifying at least one unique exogenous variable associated with each crisis mechanism.

(4) Since a crisis involves a fall in the demand for domestic assets, we can go beyond the simplification that domestic money is the only relevant "asset" and examine the role of volatilities in gross asset inflows and outflows in causing a crisis given the NFA database.

4 Data and Methodology:

A. Data:

The details on the construction of the database, in particular the development of gross stocks of external assets and liabilities are in the appendix to this paper. The problem of negative stocks is inevitable since flows are accumulated for countries where there is no stock data, on the assumption that stocks were zero in the first available year. Fortunately, this problem is rare, and the adjustment required to ensure non-negative stocks was less than 0.3% of GDP in all cases. Starting with a database of over 200 countries, only those are retained that have population greater than one million and per capita GDP greater than \$1000 in 1990. All variables are in 1990 US dollars.

The database has a mix of 167 developed and developing countries over a wide variety of geographical regions with a great deal of heterogeneity in their political and institutional environments². A number of countries out of these are "new" and therefore with limited time-series data was available. Eliminating countries with less than 20 years of data for all the relevant variables leaves the results unchanged. The rationale for eliminating countries with a population of 1 million or less in 1990 since very small economies raise specific empirical issues.³ In addition, we use Bossone, Honohan and Long (2001) to distinguish countries with total M2 (money + quasi-money) less than 2 billion in 1998. In other words, if the financial system was approximately the size of the local credit union in that year, is the country more vulnerable to crises or not? Morley (1997) is used for the construction of the capital restrictions index and the political violence index. The construction of the crisis index follows the methodology of Glick and Hutchison (1999). In addition, various country-specific dummies are included, for example, political violence, rule of law, existence of black market premium on official exchange rate, current and capital account restrictions. There are several examples in the received literature on the use of such dummies. The inclusion of political variables in particular has several precedents in the literature. Other authors have controlled for this by including dummies for incumbent electoral victory or loss, change of government or of finance minister, legal or illegal executive transfer (Eichengreen *et al*, 1995; Klein and Marion, 1994) and political uncertainty. Morley's indices (Morley, 1997) are used here since

² Listed in the Appendix

they match closely the sample period while providing a measure that is adequate to the purpose at hand without being a 0-1 dummy. In a framework in which there is a limited dependent variable, this reduces the risk of co-linearity. An index of political instability was also used by Edwards and Santaella (1993), and by Milesi-Ferretti and Razin (1995).

B: Methodology:

The model is briefly outlined in this section, and a detailed explanation of the intuition behind the probit framework chosen for this analysis is reserved for the appendix. As opposed to the signals based "early warning system" type literature, the need here is for an estimation method that would be flexible to testing for the timing of the crisis as well as for threshold levels of fundamentals in as transparent a manner as possible. Several authors have used similar estimation techniques (for example, Eichengreen *et al*, 1995; Glick and Hutchison, 2001; Tornell, 1999). The event is the occurrence of a crisis. The estimated coefficients are used to infer the impact of the independent variables on the likelihood of the event taking place.

The key explanatory variables on the RHS of equation A5 (Appendix A) are total net external liabilities of the economy and an index variable for capital controls when testing the Chang and Velasco "illiquidity" argument. To test the insurance model, the appropriate explanatory variables are gross external liabilities and capital flight. The rationale behind the choice of variables was explained in Section 2: A2 and A3 above. A comparison of goodness of fit and marginal effects would allow identification of which model has superior predictive power.

Formally, as defined in Section 2: A.2 and A.3, we can write out the models we are testing as in equations 1,2 and 3.

The Nested Model:

This is a control regression in which a variety of cross-model predictors are included.

$$Crisis_{it} = F\left(\frac{bank\ credit}{GDP}, fiscal\ deficit, \frac{M2}{reserves}, capital\ in - flight, political\ violence, capital\ and\ current\ account\ restrictions, gross\ external\ liabilities\right) + \varepsilon_{it} \quad (1)$$

³ See Kraay (1998) for a discussion of these issues. ₁₁

The Insurance Model:

The variables are identified in Section 2.A2, where the model is described. The control regressors are in Table 2 at the end of this section.

$$Crisis_{it} = F(\text{gross external liabilities}, \text{capital flight}, \text{control regressors}) + \varepsilon_{it} \quad (2)$$

The Illiquidity Model:

The variables are identified in Section 2.A3, where the model is described. The control regressors are in Table 2 at the end of this section.

$$Crisis_{it} = F(\text{net external liabilities}, \text{capital flight}, \text{control regressors}) + \varepsilon_{it} \quad (3)$$

The included regressors are summarized in Table 1:

Table 1: The Explanatory Variables

FOCUS	CONTROL
log of external liabilities gross	log of fiscal deficit
log of net external debt	log of money/nongoldreserves
fall in net stock of capital flight	log of GDP
volatility in M2/non-gold reserves	change in current account deficit
Crisis (0,1)	index of political violence
GDPDUM: the variable defined as y_{it}	domestic credit to the banking sector
	real domestic interest rate-real world interest rate (bank rate/discount rate adjusted for inflation in the GDP deflator)
	Index of capital account restrictions
	Index of current account restrictions

5 Results:

This section focuses on the first objective of this paper, namely, can we find patterns in the data that help distinguish theories that are seemingly observationally equivalent.

A. The Nested Model:

“Nested” refers to the full range of first, second and “third” generation predictors for the full sample of 167 countries are included as described in equation 1.

The results are reported in Table 3. They indicate support for “third generation” models. There is also support for the role of capital and current account restrictions, gross external liabilities and for volatility in M2/non-gold reserves.

Three specifications are presented. The first includes all variables, the second, all except current account restrictions and the third, all except capital account restrictions. Overall goodness of fit is measured by the likelihood ratio test (chi-square test), which suggests statistical significance at 1%. There are 189 crisis episodes and 1489 observations. The actual probability of a crisis is 12.5% while predicted probability is 10.8%. More precisely, a crisis is called correctly if a crisis is predicted when it actually occurs. It is called incorrectly if a crisis is predicted where none occurs in which case we have a type 2 error. If a crisis occurs but the prediction is of no crisis we have a type one error. The probability of calling a crisis correctly is 55.3%. The probability of a type 1 error is 44.7% suggesting a tendency towards underestimation of the outcome, while the probability of a type 2 error is 4.7%.

(1) Fundamentals: Of these, log GDP lagged one period, gross external liabilities, log fiscal surplus (normalized so there are no negative values), log M2/non-gold reserves, gross external liabilities and domestic credit to the banking sector as a ratio to GDP are statistically significant crisis predictors with the expected sign. All are robust to changes in model specification.

(2) Political uncertainty: The variable “polvio” is a country specific score of political violence. The lower the score the worse the country is doing in terms of political stability. It enters with the correct sign, is statistically significant and robust.

(3) Capital flight: The results are mixed, depending on the measure of capital flight used. Ultimately the best results come by using change in capital flight measure “a”, computed by the residual method (Claessens, 1998; Dooley, 1998). However, though the sign is correct (note that this variable is minus capital flight so we expect it to have a negative sign), and its inclusion improves the overall predictive power of the probit model, it is not statistically significant. This probably has something to do with measurement errors in the case of several developing countries.

(4) Current Account: Current account restrictions appear to be significant, and enter with a positive sign, i.e. the greater the restrictions on the current account, the higher the probability of a crisis. This is as expected given that current account restrictions hinder the ability of agents to smooth consumption, thus increasing perceived vulnerability to a crisis. The predictor is not robust however, and is dominated by capital account restrictions.

(5) Capital Account: Capital account restrictions are significant and enter with a positive sign. This predictor appears to be robust, and outperforms current account related variables. Thus, liberalizing the capital account does not increase the likelihood of a crisis.

B: Distinguishing between liquidity and insurance models:

The most encouraging results are under this heading. The results are reported in Table 4. The distinction from the previous sub-section is that we are now specifically contrasting the insurance and illiquidity models of currency crisis. We have 189 and 171 currency crisis episodes out of 1486 and 1282 observations for the insurance and illiquidity models respectively. Actual vs. predicted probability of a crisis is 12.5% vs. 10.8% for the insurance model, and 13.3% vs. 11.7% for the liquidity model. Once again, conditional probabilities of calling a crisis correctly are computed, i.e., of making a type 1 or a type 2 error. These are

56%, 44% and 4.7% respectively for the insurance model and 53%, 47% and 4.5% respectively for the liquidity model.

The overall goodness of fit is again captured by the likelihood ratio test (chi-square test), and suggests both specifications are statistically significant at 1%. The points of comparison emerge clearly as we examine the results on individual variables.

(1) Gross liabilities: Gross liabilities are highly robust, statistically significant predictors of crises, whether log-levels or change in log-levels are used.

(2) Capital flight: Capital flight also should be a predictor of crises according to this model, and is in line with our use of gross liabilities. The results are mixed. While the variable enters with the correct sign, it is not statistically significant.

(3) Net foreign assets: Netting out assets reduces the equations predictive power, and the net variable is not significant. Net liabilities are defined as gross liabilities minus gross assets, in order to be consistent across countries. An alternative would be to use external debt figures (the most comprehensive data sources being the OECD, lenders figures and the World Bank, debtors figures) but these are constructed using quite a different methodology and include all kinds of concessional and strategic lending and borrowing.

(4) Fundamentals: Once again, the control variables that are meant to represent the fundamentals are robust and significant: log of GDP, gross external liabilities, capital account restrictions and index of political violence.

6 Conclusions:

In this paper, the objective was to demonstrate how different crises that are apparently “observationally equivalent”, can be distinguished with the help of data on gross foreign liabilities. This means that different transmission mechanisms that are difficult to disentangle based on movements in the typical predictors, can be clearly identified with the help of

patterns in the new variables defined in the database. The distinction between gross and net external liabilities is used to demonstrate that models utilizing an “insurance” based logic, such as Dooley (1998) and Chin and Kletzer (1999) appear to perform better than those that rely on arguments around term structure of external debt and net external illiquidity.

However, further distinguishing between different models within this sub-category of “third-generation” models is difficult in the absence of time-series data on non-performing loans. In this context, the relatively lower output loss faced by Brazil (compared to Russia, Turkey or Argentina) in weathering the crisis has been linked to the relatively lower dollarized liabilities of the banking sector. This points to the role of moral hazard not only in crisis timing, but also in the crisis after-effects. A devaluation is much more costly for the economy if banks have large net foreign liabilities. Since insurance is a pre-requisite for the moral hazard argument to hold, these two frameworks are effectively tested together, though the availability of consistent and comprehensive data on non-performing loans would enable us to distinguish the transmission mechanism of the crisis and its consequences more clearly.

The ability of the policy maker in limiting its contingent liabilities is also crucial. This suggests that a credit line with performance conditionalities from the international financial system might be more effective than the allowing the central bank to become the lender of last resort in order to attract more foreign capital.

It is interesting that capital account restrictions are positively and robustly related to the occurrence of crises in our estimates. This is exactly consistent with Glick and Hutchison (2000), who also find that capital account restrictions increase the likelihood of a crisis. This might be because countries that have attempted capital controls in the past have been largely ineffective at implementing them, i.e., capital flight continues more or less unchecked. Capital controls may also send a signal to agents who believe that information is asymmetric, that policy makers think that fundamentals are not in line with the exchange rate. Alternatively, as in the model of Shankar (2001), agents believe that policy makers are trying to avoid an erosion of the inflation tax base, thereby triggering the belief that future government spending will rise to a growth rate no longer consistent with the peg.

Capital flight is positively correlated with crises as expected, and though the marginal effect is tiny, Tables 3 and 4 would suggest this is a significant predictor. Certainly, it appears to be a robust finding that imposing capital restrictions is unhelpful in lowering the likelihood of a currency crisis. The role of current account restrictions is less clear on the likelihood of crises, though they enter with a negative and significant coefficient in the output equation, as expected given previous related work. In Hutchison (2001), for example, the disruption of balance of payments is a source of output and employment losses.

The political variable used in the regressions is highly robust and statistically significant. It is meant to capture uncertainty regarding the policy maker's future objectives, though potentially this is just one possible interpretation.

Appendix A

The probit framework referred to in Section 4B:

Single Equation Approach:

The intuition behind the probit model is as follows. The ability of the policymaker to ward off the crisis ($Crisis^*$) is not something that can be observed directly. The actual event of a crisis occurring can however be directly observed. This can be expressed in equation (A1) as follows.

$$Crisis_{it}^* = F(\beta' v_{it}) + \varepsilon_{it} \quad (A1)$$

where,

$$\varepsilon_{it} = N(0, \sigma^2)$$

such that the disturbances are independent across groups, though they may be correlated across time.

Further,

$$Crisis_{it} = \{1 \text{ if } Crisis_{it}^* < 0, 0 \text{ otherwise.}\}$$

and,

$$\begin{aligned} Crisis_{it}^e &= E[Crisis_{it}^* / I_t] \\ &= F(\beta' v_{it}) \end{aligned} \quad (A2)$$

This is equivalent to the statement that,

$$Probability(Crisis_{it}=1) = F(\beta' v_{it}) \quad (A3)$$

and,

$$Probability(Crisis_{it}=0) = 1 - F(\beta' v_{it}) \quad (A4)$$

$Crisis^*$ = unobservable ability of policy maker to ward off a crisis.

" $Crisis$ " refers to the crisis index.

$Crisis = 0$ if no crisis occurred; $= 1$ if a crisis did take place.

" i " indexes the n countries, while t refers to the time subscript.

" v " is the matrix of variables

β is the vector of parameters that reflect the impact of " v " on the probability that the crisis occurs.

Using equation A2, the expectation that a crisis will occur is thus the estimated dependent variable from equation A5.

$$Crisis_{it} = F(\beta' v_{it}) + \varepsilon_{it} \quad (A5)$$

Thus, equation (4) says that the expected likelihood of a crisis is a non-linear function " F " of the variables included in " v ". This is also referred to as a univariate probit model.

The solution method is based on maximum likelihood estimation. The joint probability or likelihood function follows a normal distribution in case of the probit model. Each observation is a single draw from a Bernoulli distribution, and the success probability is $F(\beta' v)$.

Inference in the probit framework is based on predicted probabilities from which we can estimate marginal effects. The marginal effects capture the individual variables' impact on the likelihood of the occurrence of the dependent variable, in this case, a currency crisis.

The marginal effects are interpreted as follows:

$$\frac{\partial E[Crisis_{it}]}{\partial v_{it}} = \phi(\beta'v)\beta \quad (A6)$$

$\phi(t)$ is the standard normal density and is computed following Greene, 1996. Thus, a 1% change in the explanatory variable generates a change in the probability of a crisis occurring given by the RHS of equation A5.

Appendix B

Table 2: Summary of Previously Used Crisis Predictors and the Underlying Rationale

<i>Type of Model</i>	<i>Transmission Mechanism</i>	<i>Empirical Implications</i>	<i>Predictors used in previous studies</i>	<i>My Variables</i>
A. Links output and currency crises: example: Mendoza and Uribe (1999), Shankar (2001)	Firms, individuals and the government interact in a framework in which the probability of a crisis enters an equilibrium business cycle model	Reserves and demand for money are crisis predictors; Currency crises are followed by recessions	Numerical calibration using Mexican data	Volatility in government spending, M2/ reserves, control “fundamentals”, measures of capital flight, gross external liabilities, and GDP growth.
Links output and financial crises: example Hutchison and McDill (1999), Hutchison (2001)	Failure of domestic financial intermediation	Banking crises are accompanied by prolonged recessions	Deposit Insurance, Financial Liberalization, Moral Hazard dummies, growth in GDP & real credit, nominal and real interest rates, inflation, movements in stock prices, fiscal deficit, M2/Reserves, rate of nominal depreciation.	n.a

Table 2 continued

Type of Model	Transmission Mechanism	Empirical Implications	Predictors used in previous studies	My Variables
B. Standard First-generation Model example: Krugman (1979)	Worsening fundamentals causes fall in government reserves	Fall in international reserves, worsening fiscal deficit pre-crisis, no policy change post-crisis	Fiscal Deficit, real GDP, government consumption, measures of domestic credit: examples: Collins, 1995; Kaminsky and Reinhart, 1996.	Same
First-Generation Stochastic Models and target zone models: Krugman and Rotemberg (1991), Calvo (1996), Flood and Marion (1996), model outlined in Shankar (2001)	There is a stochastic element either to the demand for domestic money or to the nominal exchange rate	The nominal exchange rate has a random walk component	Volatility in M2/reserves: example: Maloney and Galindo, 1998.	Volatility in M2/reserves, fiscal deficit, demand for domestic assets, government consumption, measures of capital flight.
Second Generation Models. examples: Flood and Garber (1984), Obstfeld (1994,1996)	Worsening exchange rate expectations manifest in either higher wage demands or increased burden of servicing government debt through seignorage.	Expectations become self-fulfilling as devaluation is one of many possible equilibria: higher interest rates and expansionary monetary policy post-crisis	Expectations proxies such as interest differentials growth in real wages, net government debt, both domestic and foreign, net errors and omissions as proxy for capital flight: examples: Kaminsky <i>et al</i> , 1997.	Expectations; net external debt; public debt

(Table 2 continued)

Type of Model	Transmission Mechanism	Empirical Implications	Predictors used in previous studies	My Variables
<p>Third - Generation Models:</p> <p>(a)Liquidity crises or bank runs</p> <p>(b)Insurance Models</p> <p>(c)Moral Hazard</p> <p>examples: Dooley (1998), Chinn and Kletzer (1999), Chang and Velasco (1997).</p>	<p>(a)Domestic economy is perceived as being over-extended causing a run on the banks as investors want out before the expected devaluation; adverse shocks are amplified by the weakness of the domestic financial sector.</p> <p>(b)In insurance models, expectations do not jump, but central bank is monetizing the banking sector's deficit: the government is lender of last resort to domestic financial sector.</p> <p>(c)Imperfect information/informational asymmetries lead to a financial crisis that spill over into a currency crisis</p>	<p>Increase in inflows pre-crisis; drawing down of reserves once this is reversed; higher domestic banking activity pre-crisis;</p> <p>increase in domestic credit to the banking sector;</p> <p>worsening exchange rate expectations as in second-generation models;</p> <p>possibly worsening fundamentals;</p> <p>coincidence of financial and currency crises</p>	<p>Expectations proxies such as interest differentials growth in real wages, net government debt, both domestic and foreign, net errors and omissions as proxy for capital flight; domestic credit to the banking sector; increase in bank activity; various macro fundamentals: examples: Corsetti <i>et al</i> 1998; Chinn and Dooley, 1998;</p>	<p>Gross external liabilities (loans,equity and FDI) as well as net external short-term debt.</p>

Table 3⁴
Dependent variable: Currency crisis (0 = no crisis, 1=crisis)
Methodology: Univariate Probit Model
Model: Nested Model
Robust Standard Errors: Huber/White/Sandwich Estimates

Explanatory Variable	Marginal Effect Computed at Mean, % (Z-Statistic)		
	(1)	(2)	(3)
Fall in capital flight	-0.001 (-3.99)	-0.001 (-3.92)	-0.001 (-3.94)
Gross external liabilities (t-1)	4.97 (4.01)	5.45 (4.16)	5.49 (4.19)
Log of fiscal surplus	-0.410 (-3.0)	-0.370 (-2.74)	-0.385 (-2.83)
Log of M2/non-gold reserves	2.55 (3.81)	2.39 (3.66)	2.37 (3.61)
Current Account Restrictions	4.77 (2.70)		1.63 (0.87)
Log of GDP (t-1)	-2.97 (-2.64)	-3.00 (-2.62)	-3.03 (-2.65)
Domestic credit to the banking sector	-0.071 (-2.0)	-0.069 (-1.96)	-0.070 (-1.96)
Index of political violence	-3.21 (-2.59)	-3.12 (3.97)	-2.90 (-2.38)
Capital Account Restrictions		8.38 (3.97)	7.75 (3.31)
Summary Statistics			
Likelihood Ratio (χ^2) (critical value)	79.6 (21.96)	78.6 (21.96)	78.2 (21.96)
Log likelihood	-525.2	-519.3	-518.8
No. of crises	186	186	186
No. of observations	1489	1486	1484
Actual Probability	12.49%	12.52%	12.53%
Predicted Probability	11.07%	10.76%	10.77%

⁴ Bold indicates significance at 5% or less. Z-statistics are reported in parentheses

Table 4 ⁵
Dependent variable: Currency crisis (0 = no crisis, 1=crisis)
Methodology: Univariate Probit
Model: Insurance vs. Liquidity
Robust Standard Errors: Huber/White/Sandwich Estimates

Explanatory Variable	Marginal Effect Computed at Mean, % (Z-Statistic)	
	Model A: Insurance	Model B: Liquidity
Fall in capital flight (t-1)	-.001 (-3.92)	-.00001 (-1.13)
Gross external liabilities (t-1): Model A Or change in net external liabilities: Model B	5.45 (4.16)	.096 (1.27)
Log of fiscal surplus	-.371 (-2.74)	-.353 (-2.29)
Log of M2/non-gold reserves	2.39 (3.66)	3.13 (4.35)
Log of GDP (t-1)	-3.00 (-2.62)	1.24 (1.98)
Domestic credit to the banking sector	-.069 (-1.96)	-.041 (-1.11)
Index of political violence	-3.12 (-2.63)	-3.01 (-2.28)
Capital Account Restrictions	8.38 (3.97)	8.25 (3.50)
Summary Statistics		
Likelihood Ratio (χ^2) (critical value)	78.69 (21.96)	60.92 (21.96)
Log likelihood	-519.36	-469.5
No. of crises	186	171
No. of observations	1486	1282
Actual Probability	12.52%	13.34%
Predicted Probability	10.76%	11.71%

⁵ Bold indicates level of significance 5% or lower. Z-Statistics are in parentheses.

Appendix: Constructing the Data Set

The goal of the database was to obtain international investment positions of countries by constructing estimates of foreign assets and liabilities and their subcomponents for 173 countries for the period 1960-97, using data from the balance of payments, Recent Economic Development Reports of the IMF and various country specific sources detailed in the appendix where required (See Kraay, Loayza and Serven, 1999). The estimates are based on existing stock data, supplemented by cumulation of flow data with the appropriate valuation adjustment. For foreign direct investment, since the estimates are highly sensitive to the valuation adjustment made, we include more than one version of the data. For FDI and equity data, in addition to the estimation at “historical” cost, we constructed stock measures that reflect changes in market prices and exchange rates. We also construct two measures of capital flight with the details given below.

We start by presenting the accounting framework that highlights the link between balance of payments flows and the stocks of assets and liabilities. Next, we will look at the formulas used in the flow cumulation exercise and at the valuation adjustments (including depreciation).

A3.1.1: Balance of Payments Accounting:

The net external position of the economy, its *NFA*, is given by the sum of the net debt position, the net equity stock position and the net FDI stock position. Net position refers to gross assets minus gross liabilities.

$$NFA_t = FDIA_t + EQA_t + LA_t + RSM_t - FDIL_t - EQL_t - LL_t \quad (1)$$

Where,

FDIA = Foreign Direct Investment Stock of Assets

FDIL = Foreign Direct Investment Stock of Liabilities

EQUA = Equity Asset Stocks

EQUL = Equity Liability Stocks

LA = Other Loans Asset Stocks

LL = Other Loans Liabilities Stocks (henceforth external debt)

RSM = Foreign Exchange Reserves

We next discuss how we obtain the NFA for a country when direct stock measures of all the right hand side variables are not available.

A3.1.2: Some identities: -

When direct stock measures for disaggregated assets and liabilities are not available, we estimate stocks by cumulating flow data. The convention in balance-of-payments is for capital inflows to have a positive sign and for capital outflows to have a negative sign. We correct for this by multiplying the flow data on assets (outflows) with negative one, so except for the case where repayments exceed receipts, we should have no negative asset flows. In Table I, we list the components of the balance of payments as presented in the Balance of Payments Manual, version 5.0. We treat the “below the line” items (what the IMF refers to as financing items) as sources of changes in the stock of external indebtedness.

Analogous to the definition of *NFA* above, since flows are defined as the change in the corresponding stock, the current account, *ca* can be defined as follows:

$$ca = equa - equl + fdia - fdil + la - ll - ka + fx \quad (2)$$

where *fx* refers to change in reserves

ka refers to net outflows on the capital account.

Lower case letters refer to flows.

Next, we define the cumulative current account, *CUMCA*(*t*)

$$CUMCA_s(t) = \sum_s^t CA_t \quad (3)$$

Next, we relate the cumulative flows of equation (3) to the *NFA* defined in equation (1).

A3.1.3: Estimating the Net Foreign Asset Position:

We start with the assumption that we can assume that the balance of payments of the IMF provides accurate flow data (gross and net) for the capital account. Then to arrive at *CUMCA* we need only an assumption on the country's initial wealth. We use all the available stock data filling the gaps with cumulated flows according to the following formula:

A3.1.3.1: Other Loans (non-equity assets and liabilities) Including Reserve Assets:

We discuss the construction of this section of the database in detail, since estimating gross positions on non-equity assets and liabilities was highly challenging. For loan (more generally, non-equity) assets and liabilities, we have the following data sources on stocks:

Industrial countries – we have some IIP data, generally incomplete, on both assets and liabilities. Rider (1994) provides some additional stock data based on national documents. Combining both sources, we very likely have at least one observation on the stocks of loan assets and liabilities for each industrial country (*this to be checked*)

Developing countries – we have data from the World Bank' *GDF* on non-equity liabilities covering 1970-present, for all developing countries. Coverage is excellent for medium and long-term liabilities, and more limited for short-term liabilities. For a few countries excluded from the WB dataset (Portugal, Singapore) comparable data can be obtained for the OECD's *External Debt Statistics*. There is no comparable source of data on non-equity assets.

Finally, for both industrial and developing countries reporting to the BIS, there is data regarding commercial bank foreign asset / liability positions.

Non-equity liabilities (LL): Because we lack minimal data on the secondary-market valuation of non-equity assets and liabilities, treatment of valuation effects will be limited to cross-currency exchange rate changes. In terms of the general accumulation equation, define $f_{LL}(c,t) = e(c,t)/P_{LL}(c,t)$ to be the unit price in US dollars of foreign liabilities (e.g., the dollar exchange rate of the DM, in the case of DM-denominated instruments); note that $f_{LL} = 1$ for dollar-denominated instruments. Hence, we have:

$$LL(c,t+1) = LL(c,t) \cdot \frac{f_{LL}(c,t+1)}{f_{LL}(c,t)} \frac{P(t)}{P(t+1)} + ll(c,t+1) - \text{forgiv}(c,t+1)$$

P refers to the US CPI (base 1990=100), while e refers to the l.c.u/US\$ exchange rate.

In fact, the GDF provides direct information on the valuation term

$$LL(c,t) \cdot \frac{f_{LL}(c,t+1)}{f_{LL}(c,t)}$$

However, the data are incomplete before 1989. In addition, GDF presents tables showing the currency composition of external debt starting in 1970, from which it would be possible to calculate the above valuation effect – although the tables show substantial amounts denominated in “other currencies” and “multiple currencies” for which the calculations would not be possible.

The term $\text{forgive}(c, t+1)$ captures debt reduction operations (forgiveness, buybacks and conversions) occurred during period $t+1$. This reduces the liabilities of the debtor country and the assets of the creditor country. Data arranged by debtor (as would be needed for the above equation) is also available from *GDF*; data by creditor is however unavailable except for official debt forgiven by OECD countries after 1990.

The empirical procedure should make use, to the extent possible, of the available stock data. Hence, for developing countries we will ignore the above accumulation equation and use directly the stock data compiled in *GDF*.

For industrial countries, we lack comprehensive information on stocks and their currency composition; forgiveness of liabilities can be safely set at zero. Hence we complement the available stock data with a simplified accumulation equation with $f_{LL} = 1$ and $forgive = 0$.

Non-equity assets (LA): Conceptually, here we have three kinds of assets:

- Foreign exchange reserves (FX)
- Recorded non-equity assets excluding reserves (RLA)
- Unrecorded non-equity assets (i.e., “flight capital”), likely to be important for most developing countries (ULA).

Hence $LA(c,t) = FX(c,t) + RLA(c,t) + ULA(c,t)$.

In comparison with the non-equity liabilities, here we face three additional data problems. First, we lack stock data – with the important exception of foreign exchange reserves (available from IFS) and commercial bank asset/liability data (available from BIS for reporting countries). Second, we do not have information on the destination and currency composition of flows. Third, by definition we have no information on unrecorded assets.

Thus, we adopt a three-pronged strategy.

For *reserves*, we will use stock data from IFS (gross reserves excluding gold).

For *recorded non-equity assets*, we will use an accumulation equation similar to that used for liabilities, but ignoring valuation effects (i.e., effectively assuming that all flows entail the acquisition of dollar-denominated assets):

$$RLA(c,t+1) = RLA(c,t) \cdot \frac{P(t)}{P(t+1)} + rla(c,t+1) - forgiv(c,t+1)$$

where data on forgiveness will be taken from the OECD (and hence limited to official debt forgiveness by donor countries, and zero otherwise).

A3.1.3.2: Domestic Capital Stock, Foreign Direct Investment:

As before, we add to the initial level of foreign direct investment, the flow of the next year. However, unlike non-equity assets, now both depreciation and valuation issues arise.

The formula is essentially the same as above:

$$K(t+1)=(1-d)K(t)V(t+1)+I(t+1)$$

where $K(t+1)$ is the stock at the end of period $t+1$ in constant 1990 US dollars, d is the depreciation rate, $I(t+1)$ is the corresponding flow during period $t+1$ in constant 1990 US dollars, and $V(t+1)$ is the valuation factor. For example, in the case of domestic capital stocks, $V(t+1)=(e(t)/e(t+1))(Pk(t+1)/Pk(t))(P(t)/P(t+1))$, where $e(t)$ is the l.c.u/US\$ exchange rate, $Pk(t)$ is the local currency investment deflator, and $P(t)$ is the US CPI.

In the case of *FDIA*, $Pk(t)$ is computed as the geometrically weighted local currency investment deflator of the destination countries with weights computed⁶ as the share of each country in the source country's outward FDI stocks in 1995⁷. It seemed safe to assume here that *FDIA* is negligible for developing countries.

For FDI in the country, *FDIL*, the relevant deflator is the local currency investment deflator in the destination country. For foreign direct investment, assets and liabilities, the depreciation rate assumed was 4%.

A3.1.3.3: Equity Investment:

⁶ Source: OECD

⁷ This is potentially a problem since it distorts the picture for earlier years given significant compositional changes. This is especially true of countries that have recently invested more in economies that experienced hyperinflation in earlier years.

The same formula is used as above. For *EQUA*, $Pk(t)$ is the Morgan Stanley World Composite Index⁸, while for *EQUL*, $Pk(t)$ is the stock market index from IFS. As for non-equity assets and liabilities, we assume depreciation is zero (or all flow data is already at market value).

A3.1.3.4: Capital Flight:

Finally, for *unrecorded non-equity assets* we implement two alternative measures:

(a) Cumulative sum of errors and omissions starting from the first date available:

$$ULA_a(c, t+1) = ULA_a(c, t) \cdot \frac{P(t)}{P(t+1)} + e \& o(c, t+1)$$

(b) For developing countries, we compute a second measure of unrecorded non-equity assets as the cumulated sum of errors and omissions, plus the cumulated sum of net non-equity liability flows, minus the foreign debt stock as reported by the World Bank:

$$ULA_c(c, t) = ULA_a(c, t) + LL(c, t) - DWB(c, t)$$

where *DWB* is the debt stock reported by the World Bank, and *ULA_a* and *LL* are constructed from the accumulation equations introduced earlier.

Based on the identities in sections A3.2.1 and A3.2.2, and in Table I in the appendix to this paper, we can obtain the net foreign asset position of the country as

$$NFA = CUMCA + KA \quad (4)$$

While we completed the calculations for 173 countries, we retain for the purposes of econometric investigation only countries that have at least 20 years of data for all variables. We are finally left with 90 countries, listed in the appendix.

A3.2. Data Sources:

⁸ Source: Global Financial Database, Morgan Stanley

Various issues of the Balance of Payments Yearbook

Balance of Payments, Version 5

International Financial Statistics

World Development Indicators

Global Development Finance

Country Specific Sources: Various Issues of

IMF: Recent Economic Developments

World Bank: Country Economic Memorandums

central bank Bulletins

Rider, Mark (1994), "External Debt and Liabilities of Industrial Countries", Reserve

Bank of Australia Discussion Paper 9405.

Balance of Payments (IFS line no. in parentheses):

Current Account (78ald): ca
Capital Account balance (78bcd): ka
Direct Investment Abroad (78bdd): $fdia$
Direct Investment in country (78bed): $fdil$
Portfolio Investment Assets (78bfd): = Portfolio Investment Debt Assets +
Portfolio Investment Equity Assets = $equa$
Portfolio Investment Liabilities (78bgd): = Portfolio Investment Debt Liabilities +
Portfolio Investment Equity Liabilities = $equl$
Other Investment Assets (78bhd): la
Other Investment Liabilities (78bid): ll
Financial account (78bjd): $fa = fdia - fdil + equa - equl + la - ll$
Net errors and omissions (78cad): $eo = ca + ka + fa + fin$
Reserves and related items (financing items) (79dad): $fin = fx + ef + imf$
Reserve assets (79ded): fx
Exceptional financing (79ded): ef
Fund Credit and Loans (79dcd): imf

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